Short Range Surveillance Link for Close Proximity Navigation during Closely Spaced Parallel

ICNS Conference
May 2005

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Marlborough, MA

Agenda

- Terminal Area Capacity Enhancement (TACEC) Overview
- Blunder Situations in Closely Spaced Parallel Approach
- Close Proximity Surveillance Challenges
- Possible approaches
- Conclusions

Terminal Area Capacity Enhancement Concept (TACEC)

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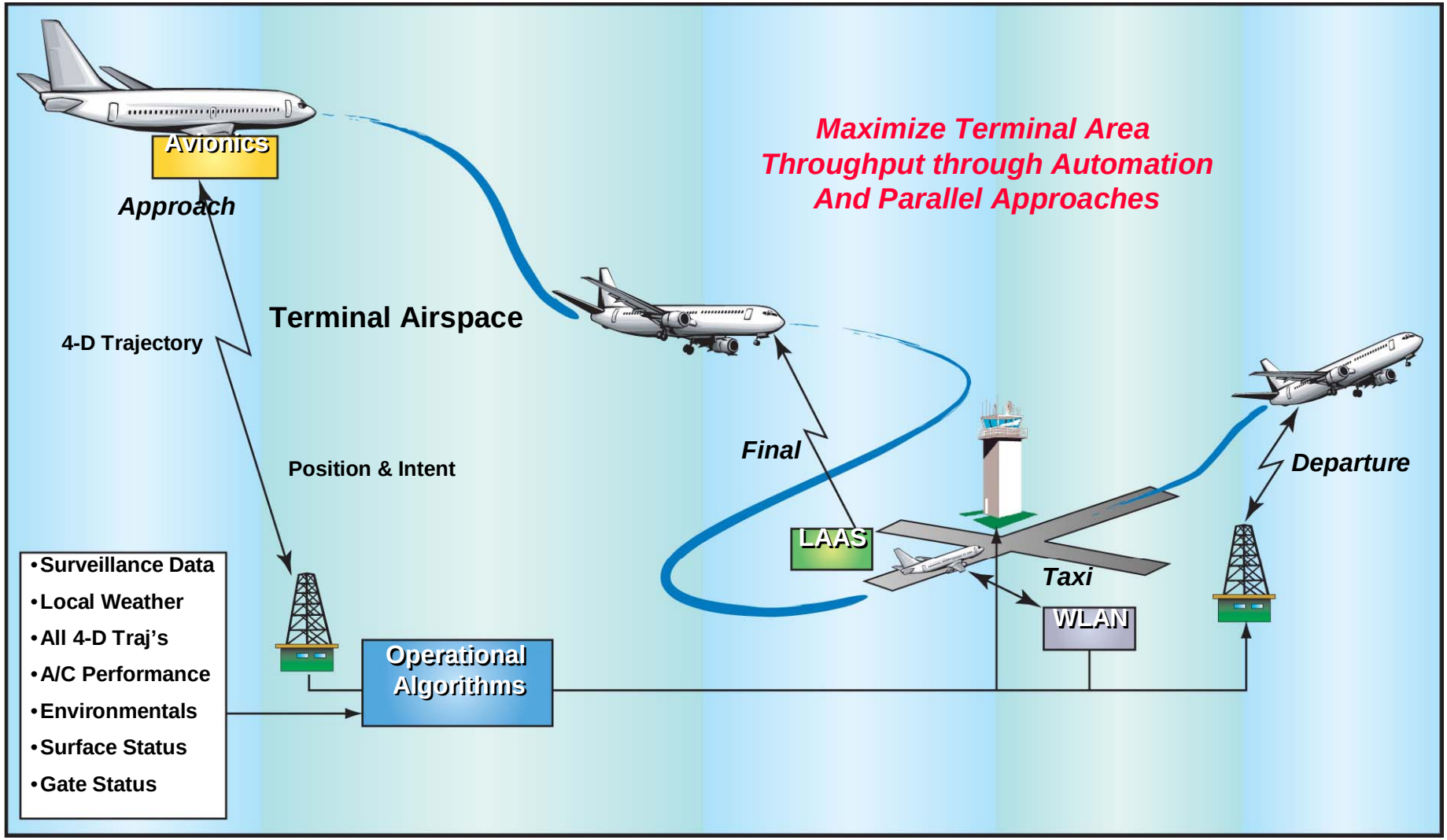

TACEC Addresses Need for Increased Terminal Area Capacity

TACEC Closely Spaced Parallel Approaches

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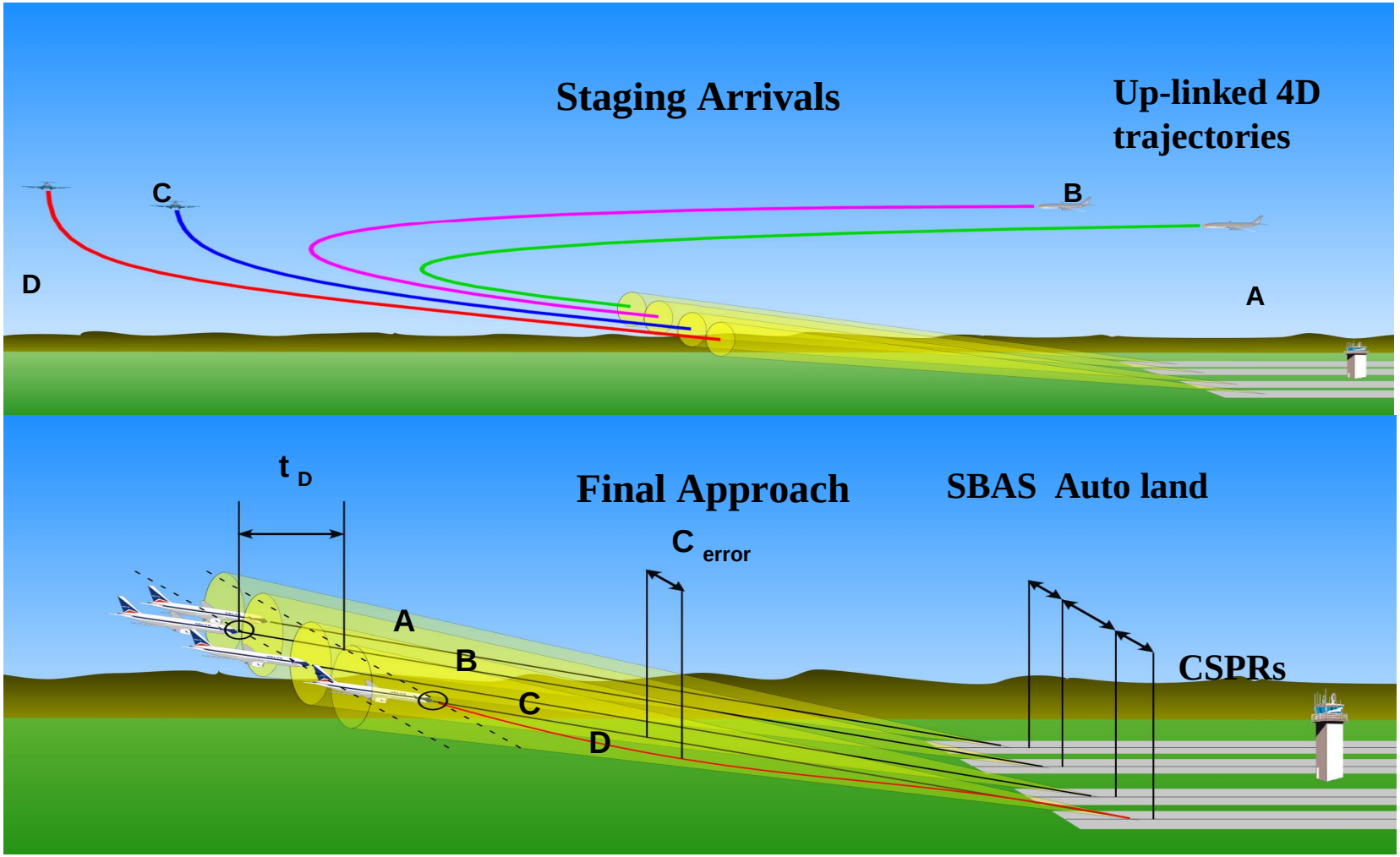
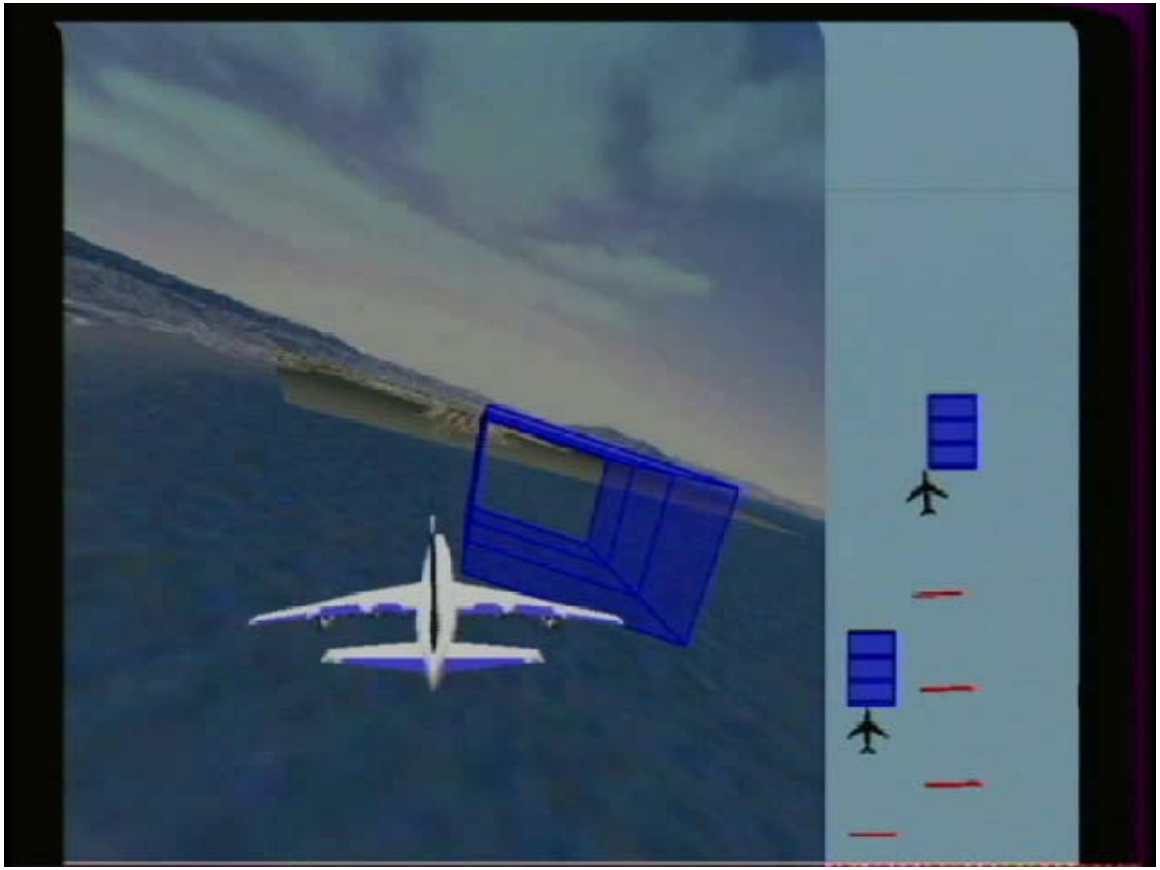


Need for Blunder detection capability in Final Approach

Blunder Situation



CSPA Surveillance

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- **Need for surveillance to accommodate situations where leading aircraft blunders.**
- **Currently CSPA allowed on runways spaced >2000 ft**
  - **TCAS II (logic version 6.04a)**
    - » **Most Commonly deployed**
    - » **Update Rate 1s**
    - » **In CSPA approaches > 2000, used only in TA not RA mode**
    - » **8 sec prior warning**
  - **TCAS II (logic version 7.0)**
    - » **Prevent issuance of multiple TA against same target during parallel approaches.**
    - » **Reduces Faulty RAs 20-40%**
  - **Precision Runway Monitor (PRM)**
    - » **Update Rate 0.5s (ASR ~4.8s)**
    - » **Allows controller to detect blunder and direct evasion**

Current CSPA delays

- 8 Seconds available from detecting blunder to avoid collision.
- Controller has up to 4 seconds to issue evasion directions, Leaving the Pilot 4 seconds to comply.
- Currently TCAS RA not used since controller left out of loop.
- Reducing runway spacing further will require reducing delay further.
- Options
  - TCAS w/ RA controller not in loop
  - TCAS w/ RA and smart auto pilot with auto escape
  - ADS-B enhanced CAS

ADS Enhanced Collision Avoidance

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- ADS-B: Automatic Position Broadcast System
- ADS-B data may be used within collision avoidance logic to reduce the number of unnecessary alerts and improve the RA maneuver processing by enabling more accurate trajectory prediction.
- Collision avoidance algorithms can be enhanced by using ADS-B state vector information.
- State Vector Report : Contains information on aircraft position and current velocity
  - Geometric Position
  - Barometric Altitude
  - Horizontal Velocity
  - Vertical Rate

Ultra Close Proximity Surveillance cont.

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- Runway spacing < 2000 ft.
- ADS-B has been investigated for surveillance capability
- ADS-B 1Hz update rate (½ Hz effective)
- Blunder Evasion Delay distribution
  - Antenna/Computer (fixed) 0.5s
  - EM Actuators (fixed) 0.5s
  - Pilot Reaction Time 0.3-2.0s
  - Autopilot Reaction (fixed) 0.5s
  - Data link/Collision Detection 1.0-2.0s
- Probability of Collision 95% Confidence interval +/- 0.3%
  - Auto Pilot + ILS (1 sigma 132 ft) = 8.994%
  - Auto Pilot + LAAS (1sigma 4.9 ft) = 0.001 %
- ADS-B lacks sufficient intent Information (blunder roll rate) to enable auto-escape.

Intent Information such as roll rate blunder and evade

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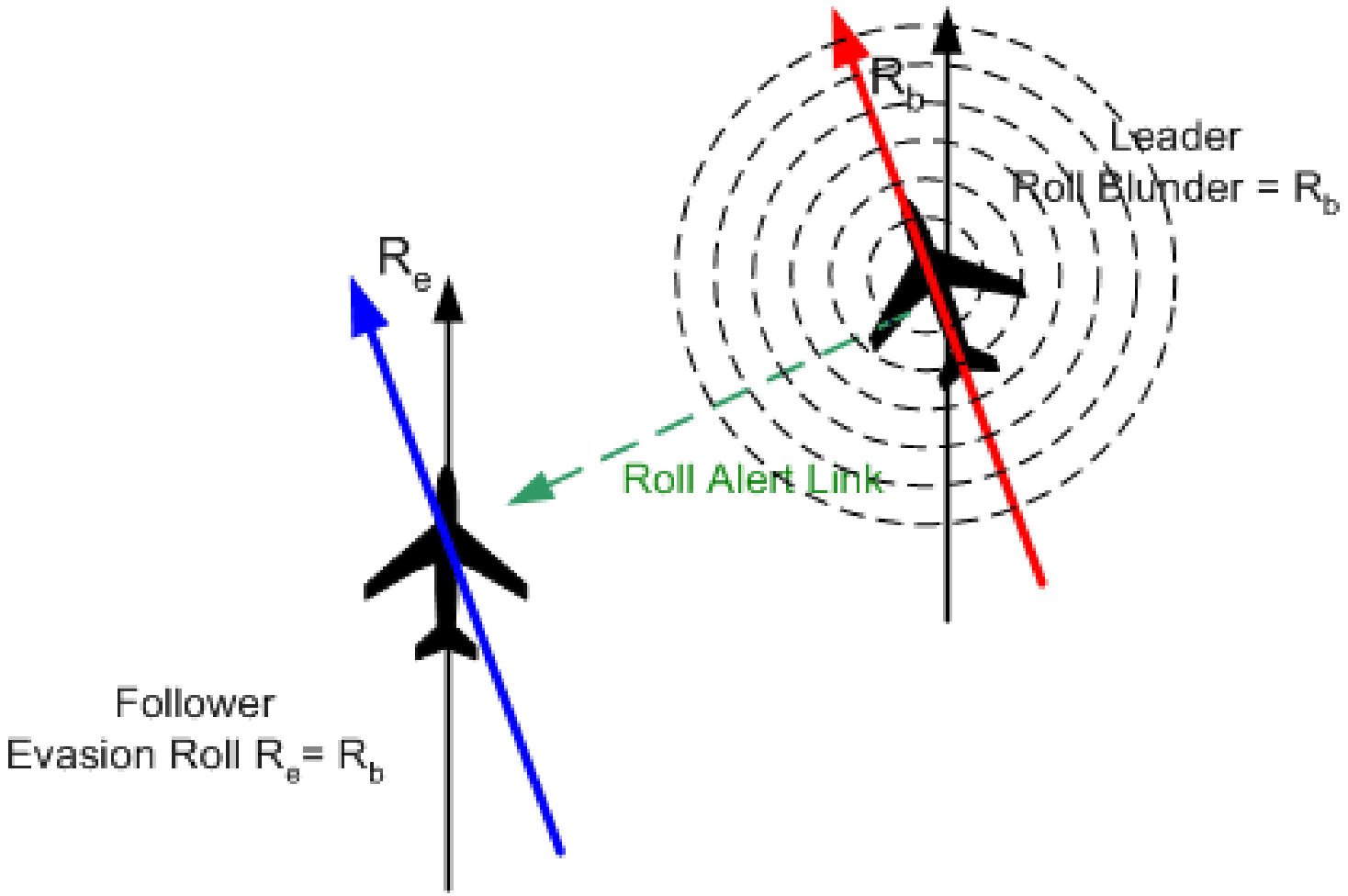

Providing Intent information

- **Implementation Possibilities**
  - **Leader only issues roll rate alert if blunder en dangers follower.**
  - **Constant broadcast of roll rate by leader during final approach**
- **Delivery Possibilities**
  - **Augmenting ADS-B**
  - **Using dedicated stand alone close short range data link to provide roll rate information.**
- **Both approaches will need automation that can use roll rate information to predict collision possibility**
- **Auto-escape automation need to compute and execute evasion path.**

Modifying ADS-B

- ADS-B Automatic Dependent Surveillance Broadcast Mode
- ADS-B system allows for surveillance without the need for Radar
- Modify ADS by incorporating close proximity alert capability
  - Include aircraft roll alert information to ADS-B message
  - Increase ADS-B update rate to greater than 2 Hz
- Pros of this approach
  - Operates in existing ADS-B link frequency bands
    - 1090 ES (Mode S)
    - UAT
- Cons
  - Need to modified ADS-B equipment
  - Range of ADS-B (Mode S) is around 100 miles, high update rate can saturate channel

Close Proximity Surveillance Link

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- Prior to final approach Aircrafts informed of final approach pairing partners via Ground/Air digital data link
- During final approach Follower navigates on Leader ADS-B
- Leader broadcasts Roll information to Follower via Close Proximity Surveillance link in Final approach.
- Aeronautical Communication
  - VDL-M3
  - UAT
- Other Commercial Technology
  - IEEE 802.11 (Wireless Ethernet)
  - IEEE 802.14 (Blue Tooth/PAN)
  - UWB

Data Link Requirements

- **Requirements**
- **Latency: < 200 ms.**
- **Min Range:**
  - **Larger Range**
    - » **prevents frequency reuse**
    - » **Too many users using shared channel**
    - » **Require more power**
  - **Too short a range**
    - » **Will require planes to be too close.**
    - » **Will result in an ineffective Alert system**
  - **Minimum Range required is related too**
    - » **Maximum Separation between Leader & Follower aircrafts**

Min. Range Requirement
Omni-directional antenna

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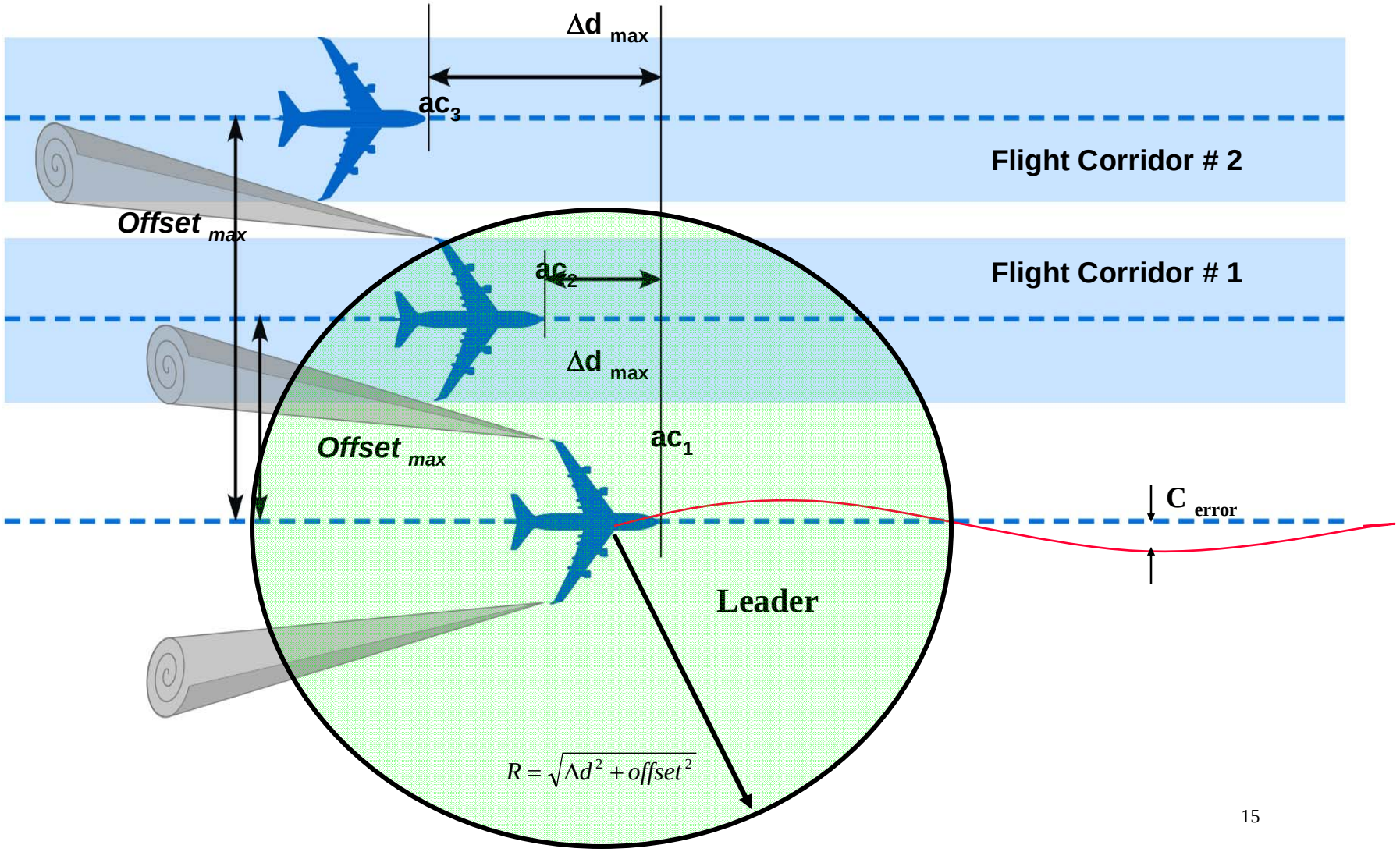

Reduced Position Error w/ Coupled Control

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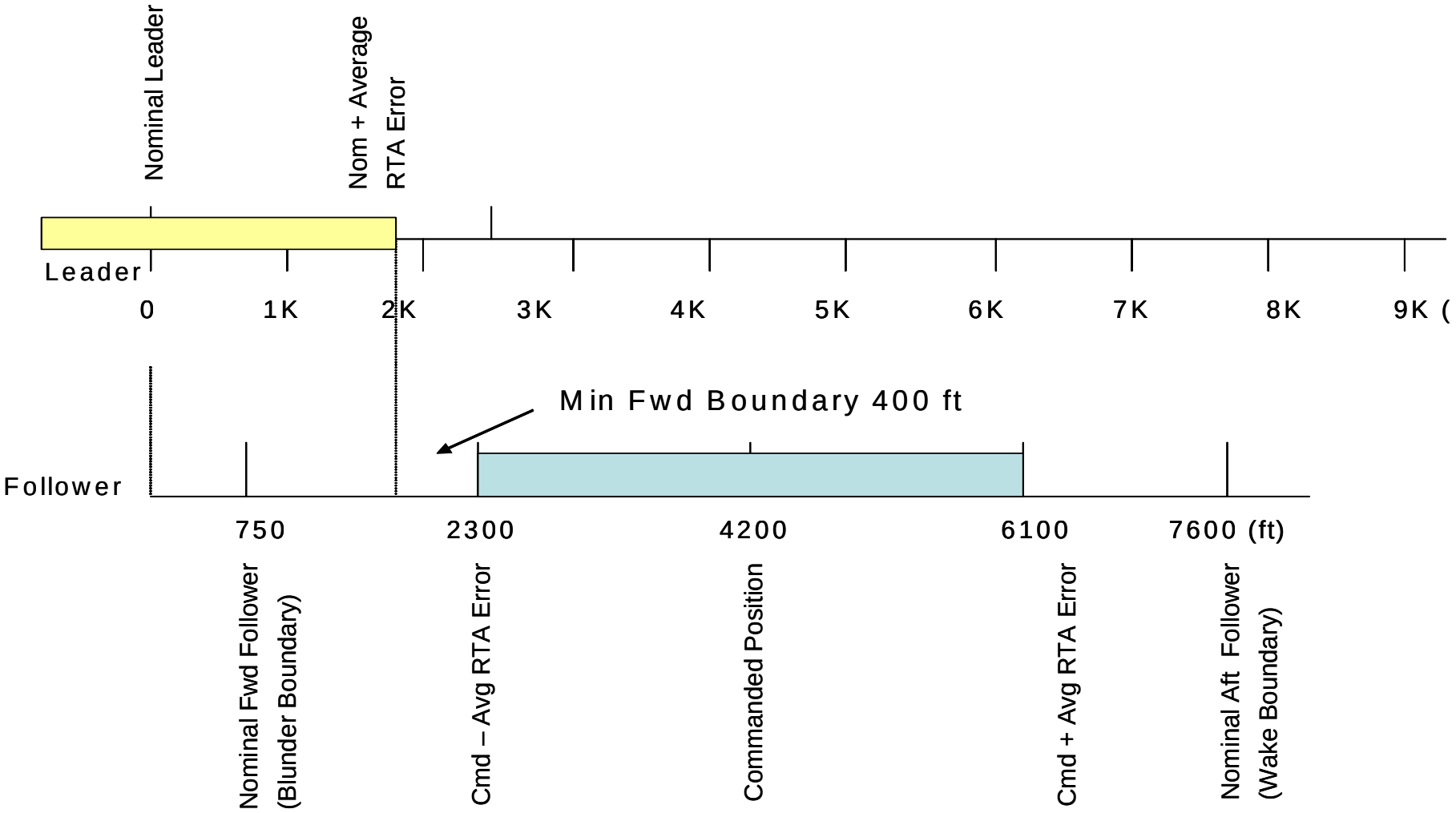

Aeronautical Link

- VDL-Mode 3 air to air link could be used
  - Pros
    - » Max latency 120 ms
    - » Existing Radios can be used
  - Cons
    - » Long Range
    - » Requires ground infrastructure
- Use Low Power Digital VHF Point to Point Link
  - Pros
    - » Operates in Existing VHF aeronautical band
    - » Low range mean frequency can be reused
  - Cons
    - » VHF band is congested, hard to find extra frequencies
    - » Vulnerable to Jamming
    - » Interoperability with existing VHF radio

Ad hoc Sensor network Technology

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- Sensor network looking at creating short term ad hoc networks that are
- Variety of commercial technology available
  - IEEE 802.11 (Wireless Ethernet)
    - » Various waveforms available FH, DSSS, OFDM
  - IEEE 802.14.4 (Low Power Long Range Blue Tooth)
  - UWB
- Pros
  - CDMA Anti Jamming Capable, Low Power Output, Short Range < 2 nm allows for good frequency reuse.
- Cons
  - Require Wideband, CSMA/CD based required low channel utilization to keep latency low.
  - Current commercial implementation of have relatively low range (typically <2000') due FCC limitation.

Conclusions

- **Blundering incidents raise the risk of collision during Closely space Parallel Approach.**
- **Current Close Proximity Surveillance requires TCAS and PRM for runways >2000’ ft**
- **Ultra Close Proximity navigation (flight paths spaced <2000’ft) required enhanced surveillance to prevent collision in the event of a blunder.**
- **ADS-B, high accuracy SBAS, smart auto-pilots can allow this if intent information is available**
- **ADS-B lacks roll rate information.**
- **ADS-B enhancement needed or a short range stand alone surveillance link.**

Questions?